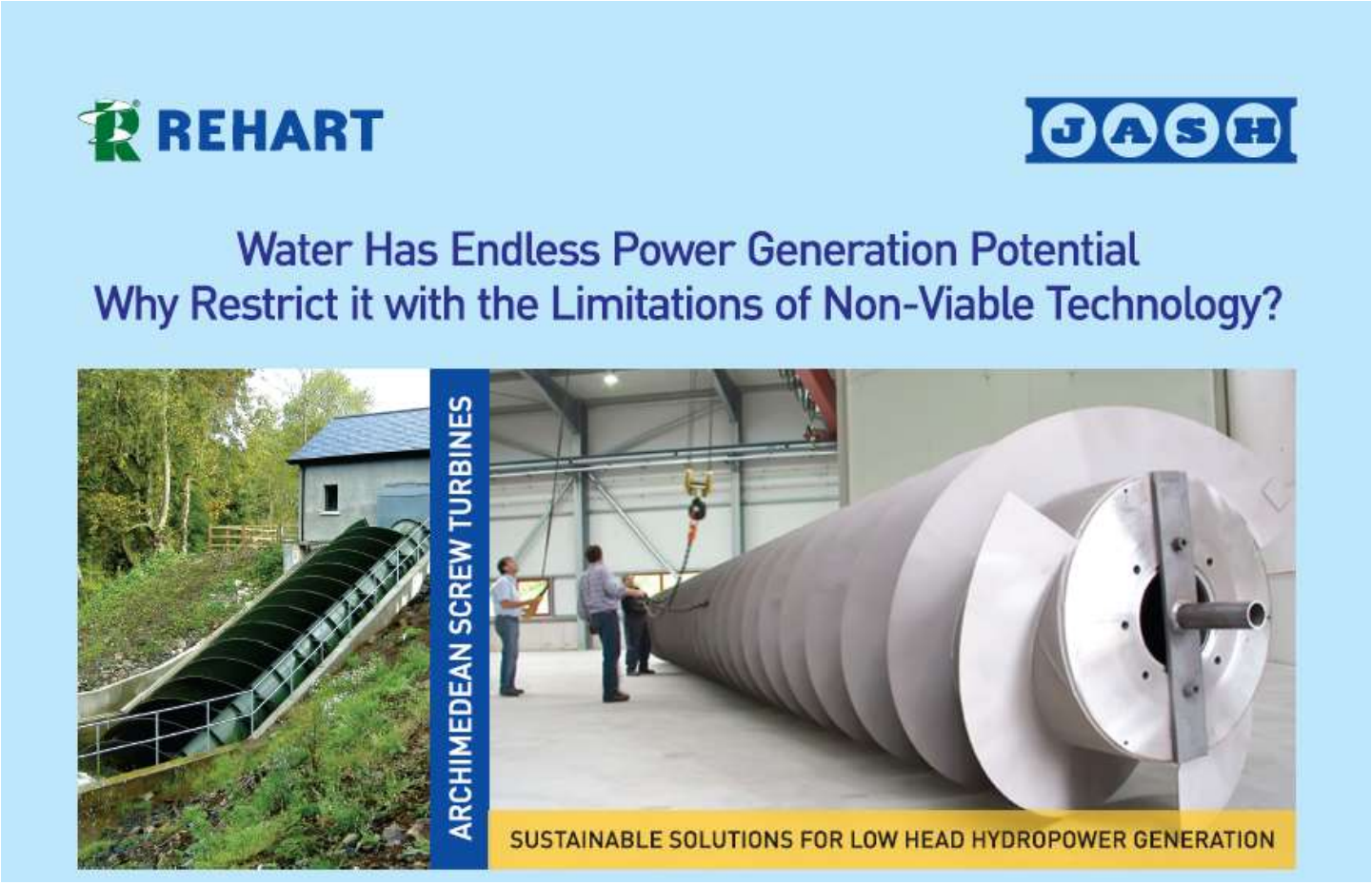
# Archemidian Screw Turbines - A Macro Perspective




There are many turbines including Kaplan, Pelton, Water Wheel, and Francis turbine available to generate electricity from water. Whereas for low head the most efficient proven technology available today in the world is **Archimedean Screw Turbine.**

This turbine is in a position to generate electricity from 0.8m to 10m head by taking the capacity ranging 0.1 $m^3$/sec to 10 $m^3$/sec with efficiency up to 85%.

## Archimedean Screw Turbine – Technology:

The Archimedes Screw was an ancient machine for pumping water from a lower level to a higher one. It is traditionally credited to Archimedes who lived between 287 B.C. and 212 B.C. In recent years, the Archimedes Screw has been installed as hydropower machine, instead lowering the water and generating power. The Archimedean Screw Turbine is a highly reliable technology for obtaining hydropower with a minimum effect on the environment.

## How does it work?

This turbine consists of a rotating screw supported within a trough by bearings at each end, with a gearbox and generator situated in the control house. The water is lowered within cells which form between the blades and the trough. The water flows through the screw and initiates its rotation. The rotation is transmitted by the gearbox and forwarded to the generator where it is then converted into electrical power. The system's inlet is equipped with a coarse screen. Thus larger foreign bodies (flotsam) are kept away from the plant. Smaller sediments can pass the screen and screw so that the natural sediment structure is kept.

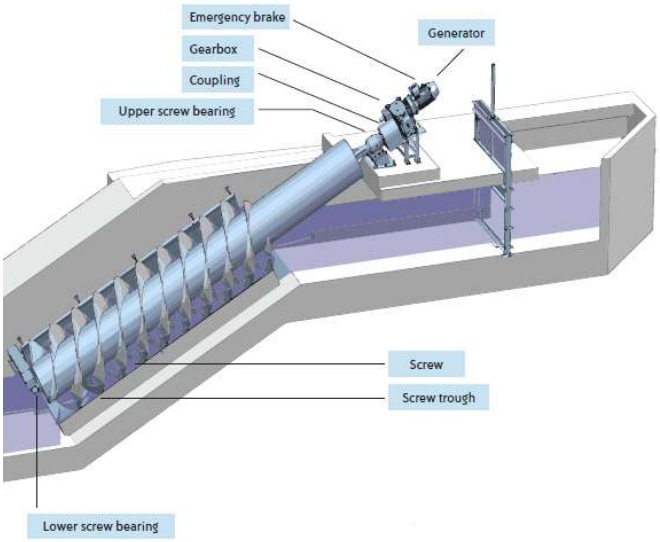



Fig-1 General Operational Layout

Archimedean screws for hydropower are used on low head/high flow sites. They can work efficiently on heads as low as 0.8 meter. Single screws can work on heads up to 10 meters, but for higher discharge more than 10 $m^3$/sec, multiple screws in parallel are generally used.

Fig-2 Two Parallel Screw Turbines (2x250 kW)

- **Low Head technology** – 0.8mtrs to 10mtrs.
- No need of penstock, hence **no impact on surrounding ecology**. Very less civil work.
- **Simple & quick installation** (5-6 months), less maintenance and very less space requirement.
- **Fish friendly. Clean & Green energy**. It's a pressure less system.
- **Debris compatible**, hence fine screens not required
- Low speed (15-40 rpm), hence **no impact of cavitation & erosion**
- **Works for varying flow** conditions, from 20% to 110%. Provides flexibility of power generation regardless of seasonal variation of flow.
- The power generated by Hydro-turbine is **Carbon Neutral**
- **Sustainable** – All parts are designed for long life cycle & can be 100% re-cycled.
- Archimedean screw Turbines adds an ability to reach remote & rural areas. It provides an opportunity of Off-Grid electrification by tapping the endless power of water. This has proven to be very efficient stand-alone technology for remote area resources.
- It's a solution to the Sewage treatment industry which suffers due to lack of power. This technology can be installed at outfalls and serve as cost effective captive use. It provides an option of increasing capacity of Hydro-power plants by installation at tail race.

JASH Engineering Ltd., India now offers the most appropriate technology to generate renewable energy using low heads, with potential applications in water conveyance canals, at outlets of mini hydro power stations and outfalls of sewage treatment plants and thermal power plants, as replacements for water wheels, at small falls at rivulets in hilly regions etc. Archimedean Screw Turbines from JASH offer practical power generation potential at heads as low as 0.8 meters and with flow as little as 0.1 $m^3/s$. JASH offers fully indigenized turbines from 5 kW up to 500 kW capacity manufactured at its modern 150,000 sq. feet facility at Indore, M.P. using proven technology from REHART GmBH, Germany – a European leader in the field.

With the ability to generate power in widely varying flow conditions, from 20% to 110% of the design flow load, these turbines provide flexibility to enable power generation regardless of seasonal variations in flow. Their robust design allows them to tolerate large sized floating wastes without decreasing generation efficiency and without risk of damage or breakdown. This eliminates the need for expensive fine screening equipment at the inlet. Furthermore, their low

rotational speed and dynamic capabilities lead to easy, low cost maintenance, long operative life and significantly lower operational costs as opposed to conventional hydropower generation equipment.

Archimedean screw turbines are ideal for low head applications, as opposed to Kaplan and Francis turbines, due to various advantages that they offer. They circumvent all the issues faced with such conventional turbines as they are suitable for low head sites and as opposed to conventional turbines, they do not require excessive civil construction on account of which a typical project can be commissioned within 6 months.

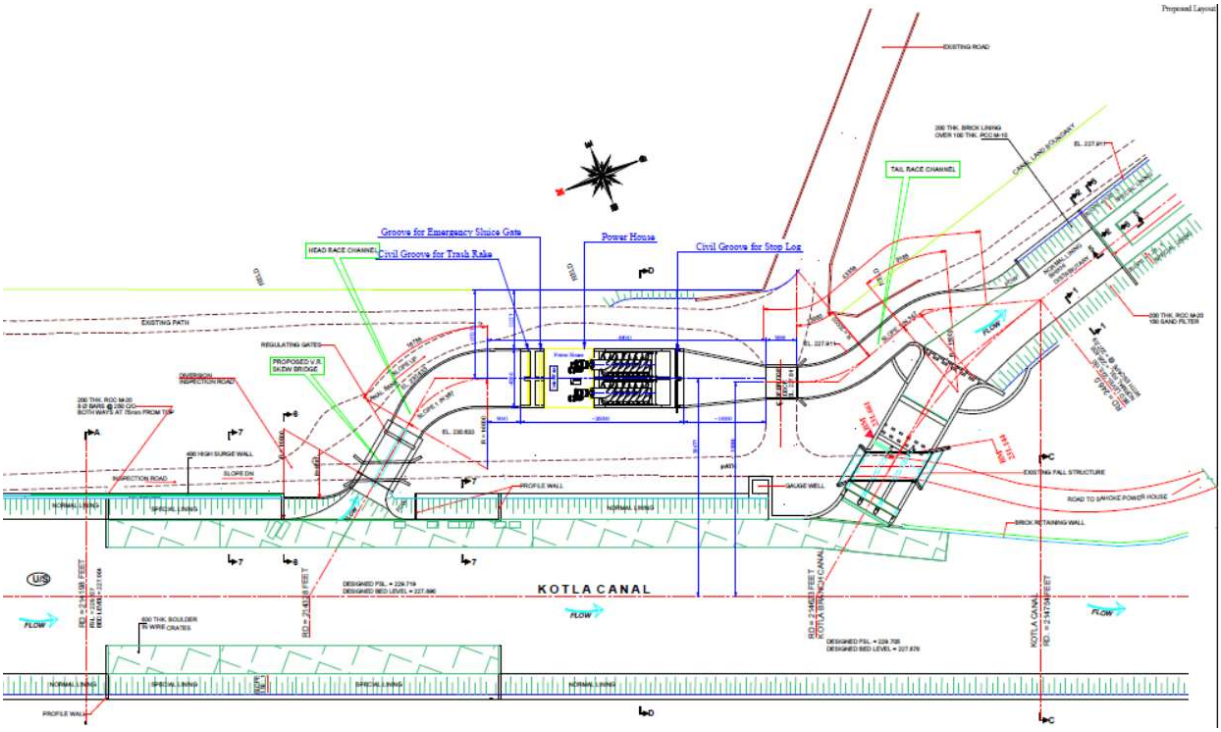
Designed to be able to allow fish and sediments to pass through (thus allowing the natural sediment structure of the river bed to be maintained) and to improve oxygenation, these turbines provide an edge over the others by allowing flora and fauna to not only survive, but thrive.

With over 50 years of experience, JASH has been serving the water industry with a wide product range that includes water control gates, mechanized screens, water hammer control valves and various other products. With its team of over 700 people spread over 4 plants in India, and with subsidiaries in USA, Austria and Hong Kong,

Fig-3 Installed Archimedean Screw Turbine


Fig-4 Satellite View of SSNNL Project

## The Bikhi site prospective

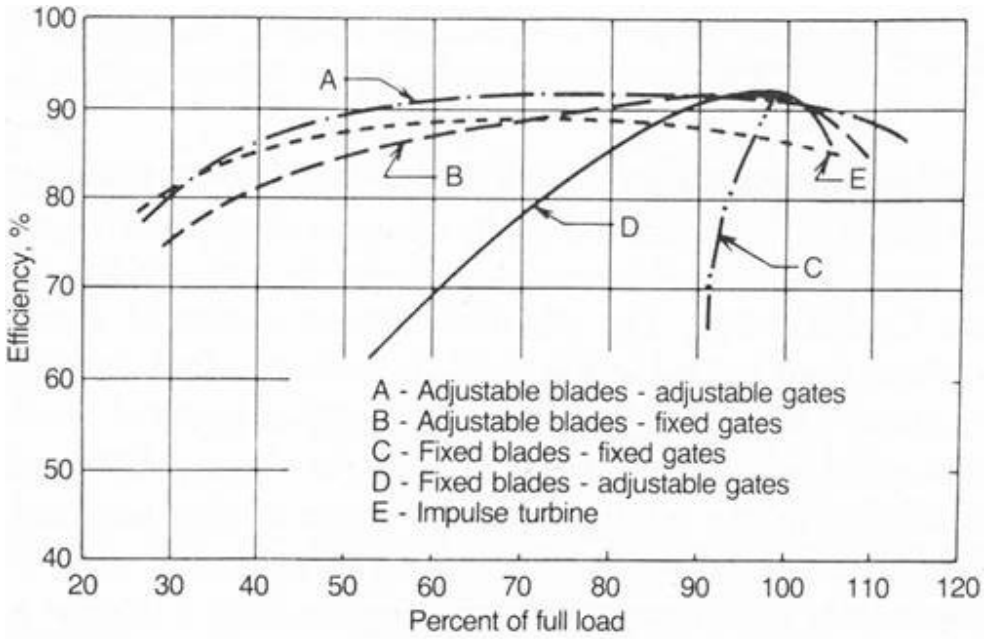



Proposed site is on an irrigation Canal, best suited for Archimedean Screw Turbines.

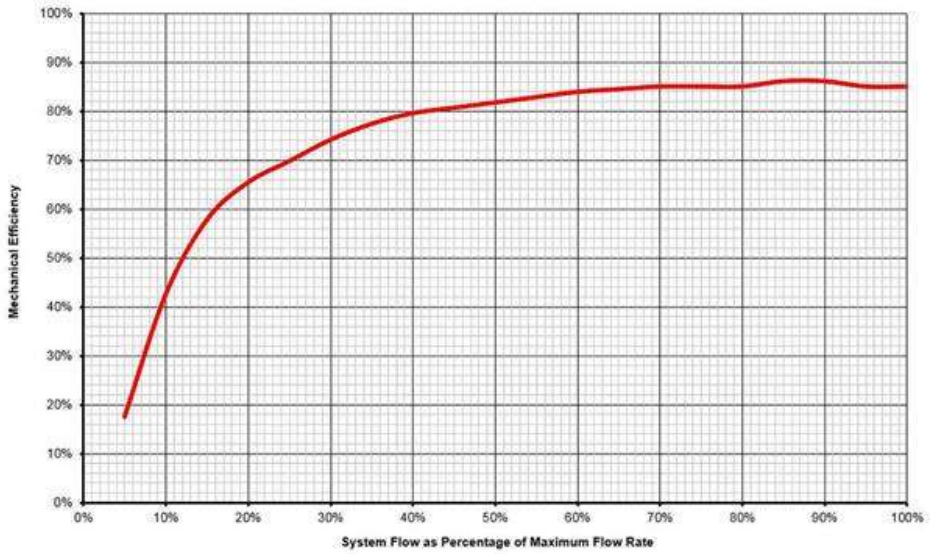
Based on annual flow data, generation capacity was evaluated.

As discussed, there is a serious flaw in the method of calculation given in shared “document” by the client. Please refer graph for efficiency of various types of Kaplan turbines below.

- **Taking uniform efficiency throughout various flows** – In Kaplan Technology, efficiency changes with flow & net head. Fall in efficiency is huge after 50%. Hence, taking a common efficiency will not represent the exact generation trend.
- **Taking average of flow** – Apart from impact on efficiency, it must be observed that all the Kaplan types stops working below 40% to 55% respectively. Running below 40% creates a risk of cavitation and once cavitation happens, efficiency of the equipment falls by 105 or more. In case of cavitation, the cost of maintenance is too high.
- With above, they are able to represent higher units, but on individual flow, the same shall be lower – Kaplan may stop working for flow lesser than 35-40%, the average theory shows generalized outcome value. 3 months per year, the flow is lesser than 40% design value.
- **Design value** – The efficiency is taken at 90% (which might be turbine efficiency & not overall system efficiency). It may be noticed that the turbines shall be designed for 13 Cumecs. At an average, for 6 months a year, the flow is 60% (or lower). Just refer the efficiency graph. There will be fall in actual efficiency.




Hence, our values are prepared in actual efficiencies & flows. It may be seen that our overall efficiency might be lower, but in terms of units generation we are higher. This is because our technology works for even lesser than 20% of designed flow and there is minimal drop in efficiency throughout the flow variation. *Our major efficiency drop starts between 30% to 40%, where most of the technology stops working.




*All the graphs are based on actual studies and are available online. Nothing is created by Jash.

## Generation calculated as per actual flow (Screw turbine)

| Design Head = 2.8mtrs. | | | | | 2012 | |
|---|---|---|---|---|---|---|
| **Max Flow** | 6.386 cumec | = 2 x 6.386 | 12.772 cumec | | **Max. Eff.** | 75% |
| **Min Flow** | 0.881 cumec | = 2 x 0.881 | 1.762 cumec | | **Min. Eff.** | 60% |

## Power Generation Year 2012; Bhikhi SHP, Punjab

| Sr. No. | Month | Discharge | | Unit-1 | Unit-2 | Cummulative Power | Units | Earning @SP = Rs5.5/unit |
|---|---|---|---|---|---|---|---|---|
| | | Cusec | Cumecs | KW | KW | KW | | |
| 1 | Jan-12 | 419 | 11.866 | 122 | 122 | 244 | 181877 | 1000323 |
| 2 | Feb-12 | 475 | 13.452 | 139 | 139 | 277 | 186232 | 1024274 |
| 3 | Mar-12 | 472 | 13.367 | 138 | 138 | 275 | 204883 | 1126855 |
| 4 | Apr-12 | 173 | 4.899 | 42 | 42 | 83 | 60076 | 330417 |
| 5 | May-12 | 448 | 12.688 | 131 | 131 | 261 | 194465 | 1069558 |
| 6 | Jun-12 | 216 | 6.117 | 56 | 56 | 113 | 81057 | 445813 |
| 7 | Jul-12 | 465 | 13.169 | 136 | 136 | 271 | 201844 | 1110144 |
| 8 | Aug-12 | 282 | 7.986 | 73 | 73 | 147 | 109352 | 601435 |
| 9 | Sep-12 | 168 | 4.758 | 41 | 41 | 81 | 58340 | 320867 |
| 10 | Oct-12 | 67 | 1.897 | 16 | 16 | 32 | 24042 | 132230 |
| 11 | Nov-12 | 264 | 7.477 | 69 | 69 | 138 | 99070 | 544883 |
| 12 | Dec-12 | 163 | 4.616 | 39 | 39 | 79 | 58490 | 321695 |
| **Total** | | | | | | | **1459726** | **8028495** |

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|---|---|---|---|---|---|---|
| **Max Flow** | 6.386 cumec | = 2 x 6.386 | 12.772 cumec | | **Max. Eff.** | 75% |
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## Power Generation Year 2013; Bhikhi SHP, Punjab

| Sr. No. | Month | Discharge | | Unit-1 | Unit-2 | Cummulative Power | Units | Earning @SP = Rs5.5/unit |
|---|---|---|---|---|---|---|---|---|
| | | Cusec | Cumecs | KW | KW | KW | | |
| 1 | Jan-13 | 233 | 6.599 | 61 | 61 | 121 | 90351 | 496931 |
| 2 | Feb-13 | 240 | 6.797 | 63 | 63 | 125 | 84059 | 462325 |
| 3 | Mar-13 | 390 | 11.045 | 114 | 114 | 228 | 169289 | 931088 |
| 4 | Apr-13 | 197 | 5.579 | 51 | 51 | 103 | 73927 | 406598 |
| 5 | May-13 | 447 | 12.659 | 130 | 130 | 261 | 194031 | 1067170 |
| 6 | Jun-13 | 318 | 9.006 | 88 | 88 | 176 | 126458 | 695521 |
| 7 | Jul-13 | 375 | 10.620 | 104 | 104 | 207 | 154096 | 847529 |
| 8 | Aug-13 | 133 | 3.767 | 32 | 32 | 64 | 47725 | 262487 |
| 9 | Sep-13 | 439 | 12.433 | 128 | 128 | 256 | 184411 | 1014262 |
| 10 | Oct-13 | 107 | 3.030 | 26 | 26 | 52 | 38395 | 211174 |
| 11 | Nov-13 | 401 | 11.357 | 117 | 117 | 234 | 168449 | 926467 |
| 12 | Dec-13 | 452 | 12.801 | 132 | 132 | 264 | 196201 | 1079107 |
| **Total** | | | | | | | **1527393** | **8400660** |

| Design Head = 2.8mtrs. | | | | | 2014 | |
|---|---|---|---|---|---|---|
| **Max Flow** | 6.386 cumec | = 2 x 6.386 | 12.772 cumec | | **Max. Eff.** | 75% |
| **Min Flow** | 0.881 cumec | = 2 x 0.881 | 1.762 cumec | | **Min. Eff.** | 60% |

## Power Generation Year 2014; Bhikhi SHP, Punjab

| Sr. No. | Month | Discharge | | Unit-1 | Unit-2 | Cummulative Power | Units | Earning @SP = Rs5.5/unit |
|---|---|---|---|---|---|---|---|---|
| | | Cusec | Cumecs | KW | KW | KW | | |
| 1 | Jan-14 | 431 | 12.206 | 126 | 126 | 251 | 187086 | 1028972 |
| 2 | Feb-14 | 448 | 12.688 | 131 | 131 | 261 | 175646 | 966052 |
| 3 | Mar-14 | 276 | 7.816 | 72 | 72 | 144 | 107025 | 588639 |
| 4 | Apr-14 | 261 | 7.392 | 68 | 68 | 136 | 97944 | 538691 |
| 5 | May-14 | 444 | 12.574 | 130 | 130 | 259 | 192729 | 1060008 |
| 6 | Jun-14 | 385 | 10.903 | 112 | 112 | 225 | 161727 | 889501 |
| 7 | Jul-14 | 444 | 12.574 | 130 | 130 | 259 | 192729 | 1060008 |
| 8 | Aug-14 | 456 | 12.914 | 133 | 133 | 266 | 197938 | 1088657 |
| 9 | Sep-14 | 137 | 3.880 | 33 | 33 | 66 | 47574 | 261660 |
| 10 | Oct-14 | 377 | 10.677 | 104 | 104 | 208 | 154918 | 852049 |
| 11 | Nov-14 | 312 | 8.836 | 86 | 86 | 172 | 124072 | 682398 |
| 12 | Dec-14 | 120 | 3.398 | 29 | 29 | 58 | 43060 | 236831 |
| **Total** | | | | | | | **1682448** | **9253465** |

## Investment Return Rate

Based on calculations of the annual generation, as per historical data, an Investment return rate was evaluated.
*Considering figures of 2014

| | | |
|---|---|---|
| No. of units of generation in a year | 16.83 | Units in lacs |
| Project Cost | 320.00 | INR in lacs |
| Subsidies from MNRE | 195.00 | INR in lacs |
| Net Investment | 320 | INR in lacs |
| Loan Amount (@ 70% of investment) | 224 | INR in lacs |
| Equity Amount (@ 30% of investment) | 96 | INR in lacs |
| Rate of Interest on loan amount | 10% | |
| Unit Cost (Cost of Generation) | 2.45 | INR |
| Per annum increase in unit cost | 3% | |
| Loan Amount Return in years | 3 | |
| Equity Amount Payback period in years | 5 | |
| Total Income or saving in 35 years | 3049.4 | INR in lacs |

| Year → | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Income | 103.6 | 106.7 | 109.9 | 113.2 | 116.6 | 120.1 | 123.7 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 | 127.5 |
| Loan Repayment | 74.7 | 74.7 | 74.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Interest Paid | 21.2 | 12.3 | 4.7 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.5 |
| O&M Costs | 4.0 | 4.2 | 4.5 | 4.7 | 5.0 | 5.3 | 5.6 | 5.9 | 6.2 | 6.6 | 7.0 | 7.4 | 7.8 | 8.2 | 8.7 | 9.2 | 9.7 | 10.3 | 10.9 | 11.5 | 12.2 | 12.9 | 13.6 | 14.4 | 15.2 | 16.1 | 17.0 | 18.0 | 19.0 | 20.1 | 21.2 | 22.4 | 23.7 | 25.1 | 26.5 |
| Depreciation | 8.4 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 16.9 | 9.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PBT | 70.0 | 73.3 | 83.8 | 90.7 | 93.9 | 97.1 | 100.4 | 103.8 | 103.4 | 103.1 | 102.7 | 102.2 | 101.7 | 101.5 | 101.1 | 100.5 | 100.0 | 107.1 | 115.7 | 115.0 | 114.4 | 113.6 | 112.9 | 112.1 | 111.2 | 110.3 | 109.4 | 108.3 | 107.3 | 106.1 | 104.9 | 103.7 | 102.4 | 100.9 | 99.5 |
| Taxes | 12.9 | 13.6 | 15.5 | 23.8 | 29.1 | 31.5 | 33.7 | 35.8 | 36.5 | 37.0 | 37.4 | 37.7 | 38.0 | 38.3 | 38.4 | 38.5 | 38.5 | 38.5 | 38.4 | 38.4 | 38.2 | 38.1 | 37.9 | 37.7 | 37.5 | 37.2 | 36.9 | 36.6 | 36.3 | 35.9 | 35.5 | 35.1 | 34.7 | 34.2 | 33.7 |
| Dep. Tax cash Benefit | 2.9 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *ACTUAL INCOME* | *29.0* | *24.3* | *25.5* | *95.2* | *93.2* | *94.4* | *95.8* | *97.4* | *96.7* | *96.2* | *95.8* | *95.5* | *95.2* | *94.9* | *94.8* | *94.7* | *94.7* | *92.1* | *89.0* | *89.1* | *89.2* | *89.4* | *89.5* | *89.7* | *90.0* | *90.2* | *90.5* | *90.8* | *91.2* | *91.5* | *91.9* | *92.3* | *92.8* | *93.2* | *93.7* |
| *Actual Cumulative Income* | *29.0* | *53.2* | *78.7* | *173.9* | *267.2* | *361.5* | *457.3* | *554.7* | *651.5* | *747.7* | *843.4* | *938.9* | *1034.1* | *1129.0* | *1223.8* | *1318.5* | *1413.2* | *1505.2* | *1594.2* | *1683.3* | *1772.6* | *1861.9* | *1951.5* | *2041.2* | *2131.2* | *2221.4* | *2311.9* | *2402.8* | *2493.9* | *2585.5* | *2677.4* | *2769.7* | *2862.4* | *2955.6* | *3049.4* |

**Above calculation is without considering Subsidy** (Client shall be eligible for 91 Lakhs to 150 Lakhs subsidy)

- Investment return – 3yrs
- Equity Payback – 5yrs